AR-009-623

DSTO-TR-0302

DSTO

Improving Feature Perception in Sonar Displays by Contrast Normalisation and Enhancement

K.K. Benke and D.F. Hedger

APPROVED FOR PUBLIC RELEASE

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

Improving Feature Perception in Sonar Displays by Contrast Normalisation and Enhancement

K.K. Benke and D.F. Hedger

Maritime Operations Division
Aeronautical and Maritime Research Laboratory

DSTO-TR-0302

ABSTRACT

In seabed surveillance, the nonlinearity of the sonar display, together with variations in brightness and contrast arising from variability in the stored sonar data, will have a direct effect on the visual discrimination of seabed features. The loss of information at the man-machine interface is due to environmental and instrumentation effects, and can be partially corrected for in real-time (i.e. at video frame rates) if the data is digitised and available for computer processing. Methods are described for normalising 2-D sonar data and for correcting for luminance compression in the electronic display. Experimental results for sidescan sonar indicate that statistical normalisation and display calibration by gamma-compensation provide a standardised presentation of data. The procedure improves both the visibility of seabed features and the reliability of visual search during routine surveillance.

RELEASE LIMITATION

Approved for public release

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

Published by

DSTO Aeronautical and Maritime Research Laboratory
PO Box 4331
Melbourne Victoria 3001

Telephone: (03) 9626 8111
Fax: (03) 9626 8999

AR No. -009-623
February 1996

Improving Feature Perception in Sonar Displays by Contrast Normalisation and Enhancement

Executive Summary

In seabed surveillance, the nonlinearity of the sonar display, together with variations in brightness and contrast, will have a direct effect on the visual discrimination of targets and seabed features. The loss of information at the man-machine interface is due to environmental and instrumentation effects, and can be partially corrected for in real-time (i.e. at video frame rates) if the data is digitised and available for computer processing. Methods are described for normalising 2-D sonar data and for correcting for luminance compression occurring in the electronic display.

Measurements of the luminance for a typical video display show compression in dynamic range by nearly 50% (from zero to mid-range) when converting from the quantised voltage signal provided by the A/D converter. The loss of information over the full grey scale is about 25%, where information is defined as the number of bits per pixel. The consequence of this problem is that low intensity targets and features may disappear from the screen altogether due to lack of contrast.

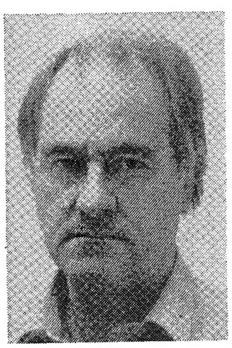
Analysis of experimental results indicates that statistical normalisation and display calibration by gamma-compensation provide a consistent presentation with improved signal detection. The normalisation approaches applied here improve the visibility of seabed features and therefore the reliability of visual search during routine surveillance. In the context of human factors, the study emphasises the importance of the human visual system in seabed surveillance and suggests that the data normalisation model must correlate with human perception rather than be limited to only a mathematically optimal criterion.

Authors

K.K. Benke
Maritime Operations Division

Kurt Benke is a Senior Research Scientist and a manager of sponsored and enabling research tasks. He received BSc and MSc degrees in Physics from Melbourne University, a PhD degree in Mathematics and Computer Science from Deakin University, and a postgraduate Diploma in Applied Statistics from RMIT. At the Kodak Research Laboratory in Melbourne, he carried out theoretical and applied research in physical optics, X-ray physics and electromagnetic scattering. Postings were completed in market research, financial analysis, quality assurance and customer relations. In late 1981 he joined the DSTO, where he completed his PhD studies and carried out research in human and machine vision, mathematical optimisation and texture analysis. Since 1988 he has been active in sonar data processing, including automatic mine detection, sonar performance assessment and search pattern optimisation in route surveillance. His current activities involve sonar system optimisation by operations research, signal processing and human factors analysis.

D.F. Hedger
Maritime Operations Division



David Hedger completed nearly two years of a Science Degree in Physics and Mathematics at Melbourne University and also has an Associate Diploma in Electronic Engineering. He was involved in the development of computer-aided methods for bomb detection for CHOGM in Melbourne in 1981. He was later involved in radiation physics instrumentation and mathematical modelling, which included 3-D graphics and digital image processing. Publications in physics and computer science include studies in X-ray microanalysis, data visualisation and the modelling of sonar performance measures. His current activities involve sonar data processing, including search pattern optimisation and automatic target detection. He is also engaged in projects aimed at sonar systems optimisation by operations research and signal processing.

Contents

1. Sidescan Display

1.1 Introduction

The image quality of sidescan sonar displays is affected by unpredictable variations in brightness and contrast when used during routine seabed surveys. Sources of this variability, include, for example, a drift in the operation of the automatic gain control (AGC) of the sonar. The most important effects of this variation are (a) the loss of detail and contrast in the sonar records, (b) diminished visual discrimination in cluttered backgrounds, and (c) a loss of displayed information available to the sonar operator.

Standardisation of the raw sidescan sonar data stored on optical disk, together with gamma-correction of the display, will produce a uniform output and an enhanced visual presentation for the sonar operator. This has obvious implications with respect to seabed discrimination and object detection during route surveillance operations. The normalisation approach applies to electronic displays in general, and should be considered whenever the human perception of visually presented data is important.

1.2 Human Visual Response

The response of the human eye to variations in brightness is known to be nonlinear (Pratt 1978). Brightness is the visual perception of luminance or intensity. The actual neural response has been observed in psychophysical experiments and can be summarised by the *Weber-Fechner* law, which states that a just noticeable difference in brightness, *B*, is a fixed proportion of the stimulus luminance, *L* (Hall 1979),

$$\Delta L / L = C_1 \Delta B \tag{1}$$

where C_1 is a constant. If one assumes that the change is infinitesimally small, and then integrates each side of this last expression, the result is

$$B = C_2 \log L \tag{2}$$

where C_2 is a constant. The visual response to changes in brightness is therefore logarithmic in nature. Inspection of a range of sidescan sonar images reveals significant variations in the background brightness levels, suggesting variability in the evoked response of the human visual system. One approach to removing the experimental variations in brightness and contrast is to apply a mathematical transformation on the raw image to convert it into a standard form (i.e. a grey level histogram of specified mean and standard deviation, as these statistical parameters

correlate with brightness and contrast, respectively). A second approach to improving human perception of the luminance variations is to compensate for the nonlinearity of the electronic display by applying an appropriate mapping function.

2. Image Normalisation

An image function can be defined by a mapping $\mathbf{R}^d \Rightarrow \mathbf{N}^d$ from the set of real numbers, $\mathbf{R}^d$, to the set of integers, $\mathbf{N}^d$, in a d-dimensional Euclidean space. The grey level, g, of a digitised image at a spatial coordinate (x,y), is given by:

$$g(x,y) \in \mathbf{S} \tag{3}$$

where

$$\mathbf{S} = \{ g \in \mathbf{N}^d \, / \, 0 \leq g \leq g_{max} \}$$

and where g_{max} is the maximum grey level. Image normalisation (also referred to as image standardisation) is the reduction of the image to a canonical form invariant to unwanted experimental changes in brightness and contrast affecting the response of the human eye (or spatial filters in pattern recognition). This operation can be achieved by histogram equalisation (Gonzalez and Wintz 1977), a process that maps the original distribution of grey levels into an approximately uniform distribution, and which is considered a maximum entropy transform in that *it maximises the amount of information conveyed by a given number of grey levels* (Laws, 1980). Image normalisation is an appropriate pre-processing stage for filtering algorithms, but is clearly not suitable for post-processing by grey level thresholding (Kittler and Illingworth 1985, Benke and Hedger 1991).

Contrast normalisation by uniform mapping, although not corresponding exactly to human visual adaptation, is appropriate for computer vision as it effectively compensates for monotonic nonlinearities in the process of image capture. The operation consists of the one-to-one mapping of the original grey levels $g(x,y)$ into new grey levels over an image area $I \times J$:

$$g_{new}(x,y) = \frac{G}{I \times J} \sum_{q=0}^{g(x,y)} n_q \tag{4}$$

Where there are significant brightness variations occurring within local regions of a single image, it may be necessary to resort to adaptive histogram equalisation. In this case, histogram equalisation is carried out within a moving window, and applied only to the pixel at the centre of the window. This operation can be implemented efficiently by adopting a fading memory approach which eliminates redundant neighbourhood computations in the pixel-by-pixel analysis. Monotonic histogram equalisation is not appropriate for all types of images in that it can produce a harsh subjective contrast,

and tends to compress the tonal scale in the shadows and highlights. It is the expansion of the mid-range grey levels that produces the improved contrast. If the amplitude of the superimposed noise is comparable with the amplitude of the underlying image features, then equalisation may enhance this noise and drown out these local features.

3. Grey Scale Mapping

Aside from normalisation, modification of the grey scale can also enhance the image structure leading to a more pleasing appearance (Benke and Hedger 1991). In the current situation, if we assume, in the first instance, that g is a random variable representing an arbitrary grey level in a sonar image, and the probability density distribution is approximately normal, then

$$p(g(x,y)) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(g(x,y)-\mu)^2}{2\sigma^2}\right] \tag{5}$$

and mapping an input image distribution, g_{old}, into an output image distribution, g_{new}, requires the specification of a new mean and standard deviation. This can be achieved by using the properties of a statistically standardised random variable, $g_z(x,y)$, which we define as

$$g_z(x,y) = \left[\frac{g_{new}(x,y)-\mu_{new}}{\sigma_{new}}\right] = \left[\frac{g_{old}(x,y)-\mu_{old}}{\sigma_{old}}\right] \tag{6}$$

Re-arranging the terms in this expression leads to the following explicit mapping operation for converting input grey levels into output grey levels:

$$g_{new}(x,y) = \mu_{new} + \frac{\sigma_{new}}{\sigma_{old}}\left[g_{old}(x,y)-\mu_{old}\right] \tag{7}$$

For a grey level range of [0 - 255], as used in the current sonar display, we set μ_{new} = 128 and $3\sigma_{new}$ = 128 (since $\mu_{new} \pm 3\sigma_{new}$ is the interval containing 99% of the image grey levels), and therefore σ_{new} = 42. The transform will force all subsequent displayed images with different grey level means and standard deviations to assume a value of 128 and 42, respectively. In practice, the histograms of many images are only approximately normal and are often skewed. This, however, will not alter the purpose of Eq. (7) as the mapping merely specifies a standard level for the mean brightness and range, without explicitly defining the distribution.

4. Display Nonlinearity

4.1 Monochrome Video Display

Until this point, normalisation of the contrast and brightness of the *stored* digitised sonar data has been carried out. An additional distortion in the data, as it is *presented* to the sonar operator, is due to video display nonlinearity. The luminance from a cathode ray tube display, L, is a nonlinear function of the input video signal voltage, v, (or in this case, the grey level, g, in the sonar record) and this effect can be approximated by the power law,

$$L(g) = (kg)^{\gamma} \tag{8}$$

where γ and k are the defining parameters (Peli, 1992). The gamma, γ, is the exponent of the power function and determines the degree of non-linearity in the characteristic curve used to convert the voltage (or grey level) to luminance. The effect of this nonlinear data transformation is to compress the luminance range in the low levels and expand the range in the high levels. There is consequently a loss of *contrast* and detail in the dark areas of the sonar record when displayed. Even with a linear analog-to-digital converter for data acquisition, it is necessary to apply gamma-compensation due to the screen nonlinearity. This nonlinearity will affect the visual communication of data to the sonar operator, but will not affect stored data being processed by a pattern recognition procedure.

4.2 Display Measurement and Calibration

An effective approach to luminance calibration is to display a stored test-chart in the form of a stepped grey-scale, and then to measure each patch on the screen with an accurate photometer (this method is also useful for the presentation of psychophysical stimuli in vision research). The power function given above is then fitted to the data. Pelli and Zhang (1991) have proposed a more general form of the power law,

$$L(g) = \begin{cases} \alpha + (\beta + kg)^{\gamma} & \text{if } \beta + kg \geq 0 \\ \alpha & \text{if } \beta + kg < 0 \end{cases} \tag{9}$$

where a is the minimum luminance and k and b are associated with the contrast and brightness controls of the monitor. This model may not effective in all cases, however, and a still more general approach would be to fit a polynomial of the form

$$L(g) = \sum_{i=1}^{m} b_i g^i \tag{10}$$

where the parameter set { b_i } is determined by least-squares regression analysis. In the application described here, the power law would appear to be a sufficient approximation and the parameters are readily estimated by fitting the function to the photometric data using regression analysis. The calibration function is valid for a particular setting of the contrast and brightness controls (noting, in passing, that manually varying the contrast control on the monitor will change the gamma).

4.3 Inverse Correction

Gamma-compensation is essentially a method for linearising the display luminance-voltage characteristic curve and can be achieved as follows. A nonlinear transformation, T, of the original voltage signals (or pixel grey levels) is necessary to compensate for the display characteristic curve, where:

$$g_{new} = T\{g_{old}\} \tag{11}$$

If the power function represented by Eq. (8) is assumed, then the compensating nonlinear transformation applied to the raw data in the file is easily shown to be

$$g_{new} = \frac{1}{k} g_{old}^{\frac{1}{\gamma}} \tag{12}$$

which produces a linear relationship between display luminance and grey level,

$$L(g_{new}) = (k g_{new})^{\gamma} = \left(k \frac{1}{k} g_{old}^{\frac{1}{\gamma}} \right)^{\gamma} = g_{old} \tag{13}$$

Linearisation of the display with this transformation could also be implemented as a device-independent look-up table. There would then be no need to change the data in the record on the disk and therefore no loss of raw data would occur.

5. Experimental Results

5.1 Experimental Apparatus

Photometric assessment of the video display was accomplished using a Minolta Chroma Meter CS-100 which incorporates a silicon photocell filtered to closely match the CIE human photopic luminosity response. The optical system includes an 85 mm f/2.8 lens with TTL viewing and an acceptance angle of 1 deg within a field of view of

9 deg. Experiments were carried out using an Electrohome 12 in monitor with flat field and relatively little planar distortion.

The test images were processed on a Mitac IBM-AT compatible microcomputer with Matrox PIP 1024 image processing board. Images were digitised at a sampling resolution of 512 x 512 pixels with grey levels in the range 0 to 255, representing 256 kBytes per image.

5.2 Experimental Method

All Results were obtained using the photometer at a range of one meter and data recorded on an external LCD panel in digital form. The luminance measurement accuracy of the photometer is 2% and repeatability 0.2%. The test pattern consisted of a computer-generated grey scale, starting from a level of zero and increasing in increments of 32 in eight steps. Each vertical bar was 64 pixels wide and measurements were taken along the horizontal line of bisection of the image.

5.3 Parameter Estimation

Quantisation of the voltage signals by the analog-to-digital converter is represented by a linear relationship, and it is perhaps intuitive that theoretically the luminance of the display itself would be expected to vary as the square of the voltage (and therefore grey level). Luminance measurements of the Electrohome 12 in video display were fitted to the power function given by Eq. (8) by least-squares regression (see Table 1 and Figure 1, which shows the fitted curve and the scatterplot). A value of $\gamma = 1.92$ was obtained for the gamma, with a correlation coefficient of $r = 0.998$ (which is statistically significant at the 0.01 level when adjusted for sample size). This relationship was found to approximate the behaviour of other displays tested, suggesting that $\gamma \sim 2$ (indicating a quadratic relationship between voltage and luminance).

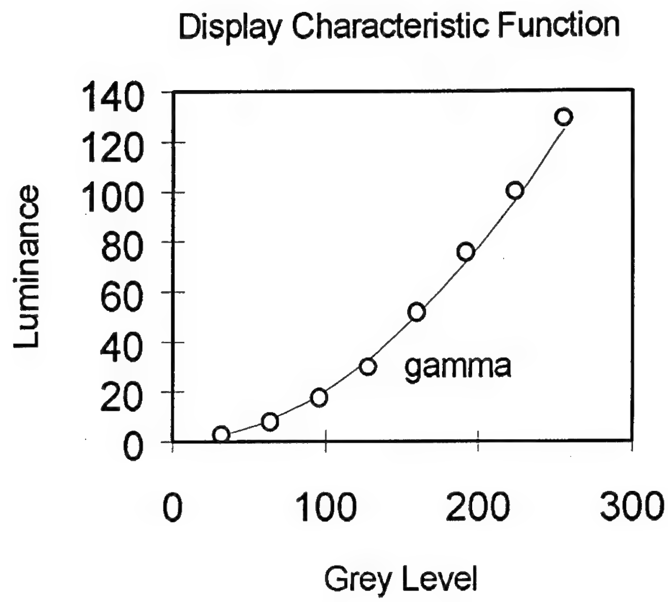


Figure 1: Display characteristic curve for the video monitor, showing screen luminance (cd/m^2) vs grey level, modelled according to the power function model of Eq. (8)

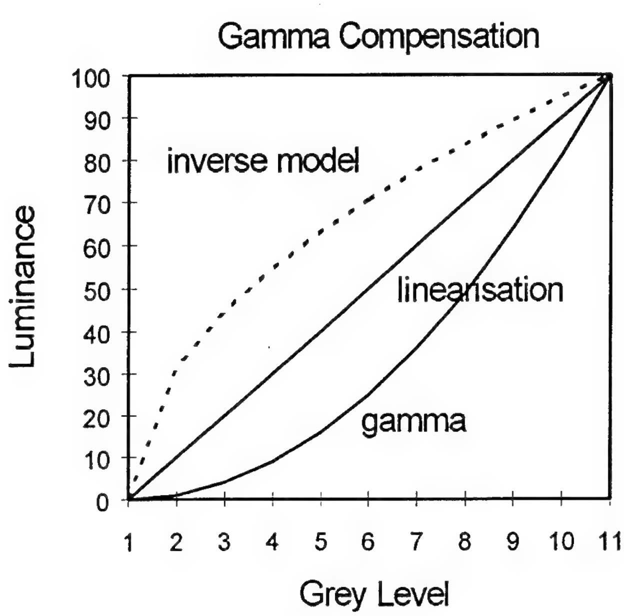


Figure 2: Gamma compensation involves applying an inverse function to the raw data (grey levels) in order to linearise the relationship between grey level and luminance and thus avoid information loss due to range compression.

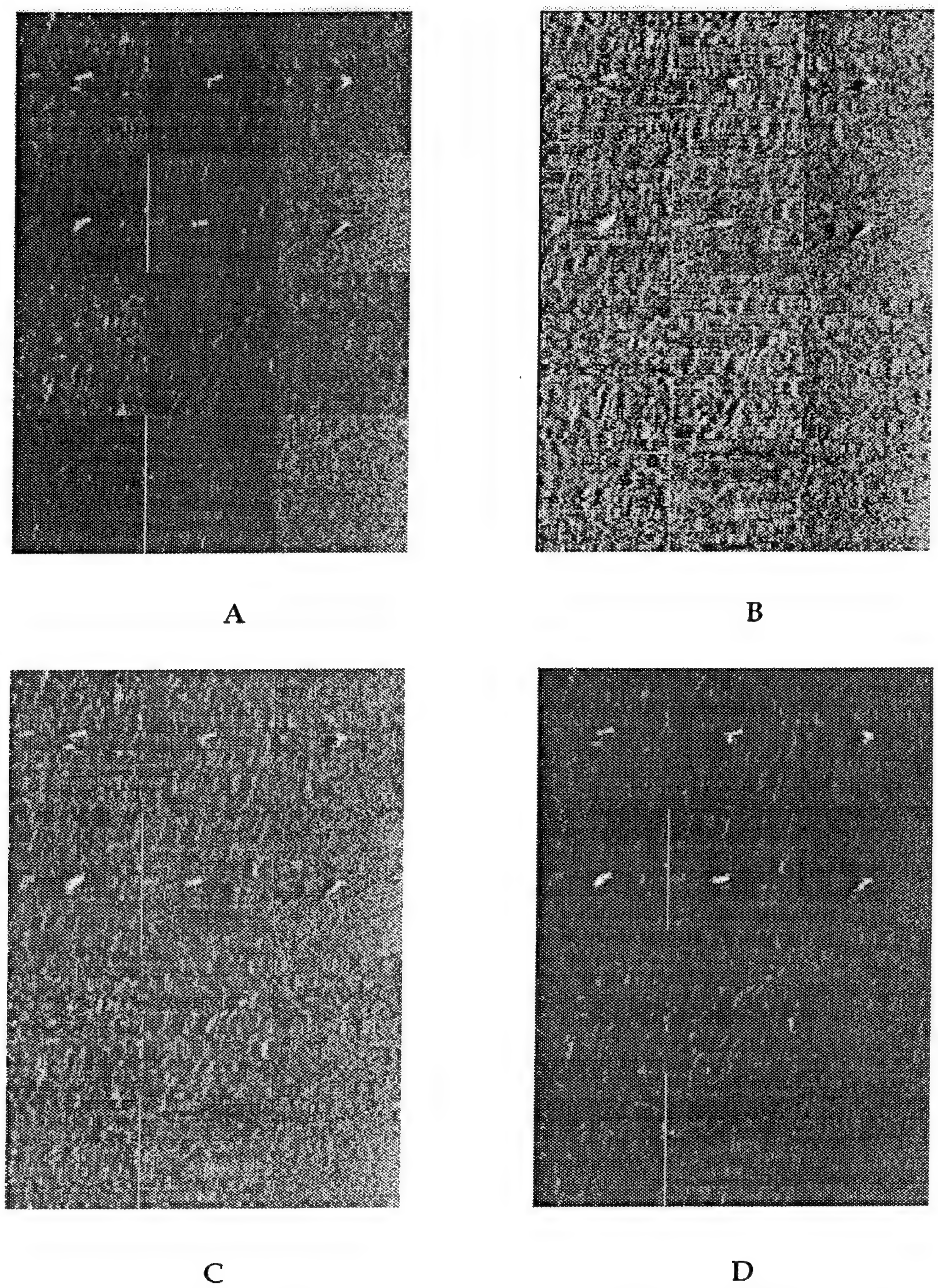


Figure 3: A. Variability in mosaic of 12 seabed images from sidescan sonar.
B: Effect of global histogram equalisation.
C: Effect of normalisation of grey scale (g.s.), $\mu = 128$ and $\sigma = 42$.
D: Effect of normalisation of grey scale (g.s.), $\mu = 70$ and $\sigma = 21$, with gamma compensation.

Table 1: Variation of luminance, L, with pixel grey level, g, from photometric analysis of the Electrohome 12 in video display terminal.

L (cd/m^2)	g
2.61	32
7.75	64
17.30	96
29.70	128
51.50	160
75.20	192
100.00	224
129.00	256

The degree of data compression indicated by the nonlinear characteristic curve in Figure 1 may be quantified as follows. Defining G as the *gain* achieved when converting from grey level to luminance,

$$G = \frac{\Delta L}{\Delta g} \approx 46\% \tag{14}$$

where the grey level scale has been normalised by $g_{max} = 256$, and similarly the luminance range is normalised by the value corresponding to this grey level. The grey level increment is taken from zero to mid-range, i.e. [0, 128]. This ratio reveals that the compression in dynamic range is by a factor of nearly 2 : 1, indicating a significant loss in information conveyed by the luminance distribution. Over the full grey scale, one quarter of the information has thus been lost, where information can be defined as the number of bits per pixel. Figure 2 shows graphically the method for linearising the data by applying an inverse function. A linear gamma represents information transfer without compression, and therefore no information loss. Gamma compensation cannot be fully appreciated without recourse to an electronic display. In Section 5.4, whilst the effect of gamma compensation for the hardcopy reproduction process is effective, it is even more pronounced for the electronic display (which cannot, of course, be demonstrated here).

5.4 Statistical Normalisation

Figure 3A shows a mosaic of 12 sidescan sonar images of the seabed from a recent sea trial in Jervis Bay, NSW, on the east coast of Australia. The upper six images show steel cylinders similar in size and shape to 44 gallon drums resting at different orientations. The lower six images show different samples of the seabed around the cylinders. The variability in contrast and brightness is clearly evident. Table 2 reveals that the magnitudes of both the mean and standard deviation of grey levels in the image histograms can vary by as much as a factor of 2. Figure 3B depicts the same mosaic following histogram equalisation. Unfortunately, although the contrast has improved greatly, the noise in the shadows has been amplified significantly and the overall effect is a visual harshness which reduces feature discrimination. This approach is mathematically effective, and indeed optimal, from the viewpoint of information theory, but is not in sympathy with luminance perception by the human visual system.

Table 2: Mean and standard deviation of pixel grey levels in the mosaic of 12 sonar images depicted in Figure 3 (reading from top row, and left to right). Normalisation by the appropriate mathematical transform reduces this variability to a single numerical value for both mean and standard deviation in all cases.

Image No.	μ	σ
1	73	31
2	50	18
3	82	33
4	55	22
5	62	20
6	113	44
7	74	32
8	49	15
9	84	33
10	54	16
11	60	17
12	109	40

Figure 3C shows normalisation by the transform given by Eq. (7), producing a mean and standard deviation of 128 and 42, respectively, for all 12 images. The visual variability in contrast and brightness has been removed and new detail in the shadow regions has emerged. The mean grey level translates into a DC luminance level that is much higher than the mean value of the original mosaic but the result has not improved *subjective contrast* (and a single small high-contrast object in a large dark

background may not have its visibility improved due to the greater weighting from the much larger background area).

Figure 3D shows normalisation to a forced mean value of 70 for *each* image (which corresponds to the mean of the original 12 unnormalised images), and a forced standard deviation of 70/3 = 23. The data was also median filtered to remove impulse noise in the original data (visible on the far right side of the mosaic in Figure 3A). The high intensities of the objects in the upper six images contained in the original mosaic were retained by thresholding, according to the following test, when applying the normalising step given by Eq.(7) :

$$g_{new}(x,y) = \begin{cases} g_{old} & \text{if} \quad g_{old}(x,y) \geq t \\ g_{new} & \text{if} \quad g_{old}(x,y) < t \end{cases} \tag{15}$$

where t = 245. The images now have uniform backgrounds and are uniformly high in contrast, which enhances the detection probability and surveillance reliability of the sonar operator. The differences between the operations performed to produce images 4B, 4C and 4D show that the mathematically optimum approach (μ =128 and σ = 42, in order to use the full grey scale of 256 levels) is not the best approach, as it fails to account for psychophysical factors, such as brightness perception and the nonlinearity of the human visual system. The approach used to produce Figure 3D is the preferred normalisation, noting the important step of setting the new mean value as the average of the 12 different means from the sea trial. This ensured a background brightness level that was within normal expectation for the sonar operator, but without the previous variability and also with improved contrast.

5.5 Look-Up Tables and Windows Bit-Maps

Given the need to describe 256 grey levels using an 8-bit byte, it is self evident that any introduction of a non-linearity into the raster will result in a loss of information. It would be convenient if a non-linearised bit-map could be presented as a combination of the original raster and a look-up table (Skinner 1995). In this way, any such modified image could be restored to its original form simply by substituting a unit-slope look-up table. There is an internationally recognised standard that can be used in exactly this way - the Windows device-independent bit-map (Borland 1991). It is necessary merely to adjust the raster to the Windows standard, and to use a palette consisting of appropriate neutral greys. An advantage of using this standard is that such an image can be imported directly into a variety of word-processing and graphics applications. Figure 4 shows the look-up table (LUT) in the sonar data stream.

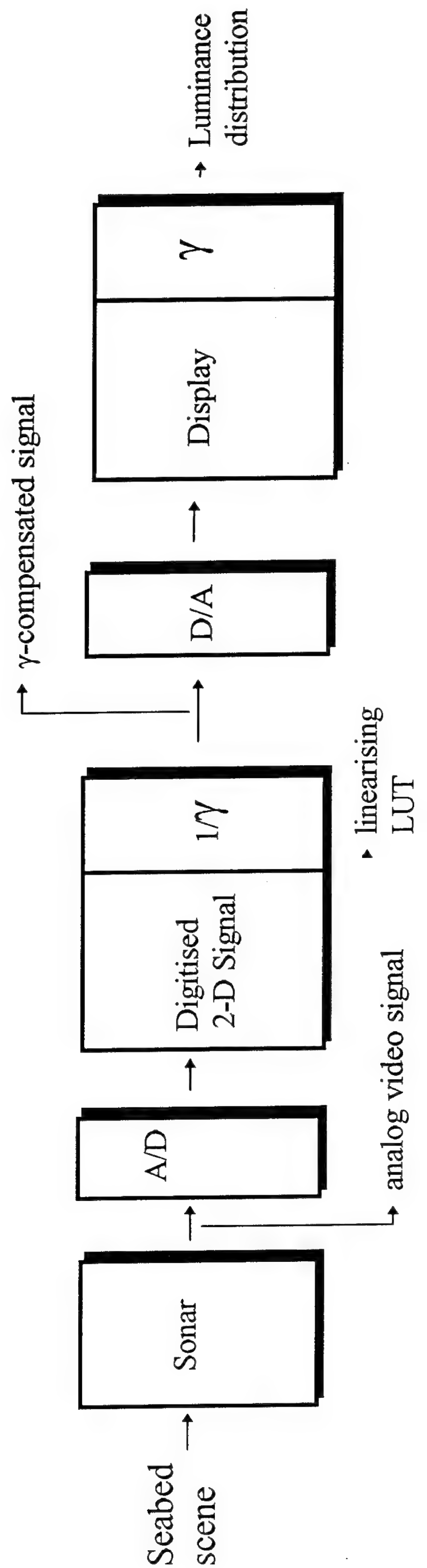


Fig. 4. Schematic diagram showing the sonar data processing stream and gamma compensation.

6. Conclusion

The advantage of statistical normalisation is that it removes variations in the brightness and contrast occurring in the raw data and also enhances the visual appearance of the sonar data when displayed. The operation provides a fixed level of brightness and contrast which improves discrimination by the sonar operator. Further enhancement is possible by correcting for display nonlinearity by gamma-compensation. These two operations in combination will provide a more consistent (and improved) level of contrast in the sonar display, with an obvious benefit to operator performance. In the context of human factors, this study demonstrates that the human visual system is an important variable in seabed surveillance and that data normalisation must correlate with human perception rather than with only a mathematically optimal criterion.

7. References

Benke, K.K. and Hedger, D.F. (1991): *Investigation of a Fast Approach for Image Enhancement in X-ray Microanalysis and Tomography,* **European J. Physics**, vol. 12, pp175-183.

Borland International, Inc. (1991). *Turbo Pascal for Windows - Windows Reference Guide,* pp. 351-355. Borland International, Inc : Scotts Valley, CA, USA.

Gonzalez, R.C. and Wintz, P. (1977): *Digital Image Processing,* Addison Wesley: Reading, Massachusetts.

Hall, E.L. (1979): *Computer Image Processing and Recognition,* Academic Press, New York.

Kittler, J. and Illingworth, J. (1985): *On Threshold Selection using Clustering Criteria,* **IEEE Trans. Syst. Man Cybern.**, vol 15, pp 652-655.

Laws, K. (1980): *Textured Image Segmentation,* Univ. of Southern Calif., USA, USCIPI Report no. 940.

Peli, E. (1992): Display Nonlinearity in Digital Image Processing for Visual Communications, **Optical Engineering**, vol. 31, pp 2374-2382.

Pelli, D.G. and Zhang, L. (1991): Accurate Control of Contrast on Microcomputer Displays, **Vision Research**, vol. 31, pp 1337-1350.

Pratt, W.K. (1978): *Digital Image Processing,* Wiley: New York.

Skinner, D.R. (1995): Private Communication. DSTO Maritime Operations Division Aeronautical and Maritime Research Laboratory (Melbourne), VIC.

Improving Feature Perception in Sonar Displays by Contrast Normalisation and Enhancement

K.K. Benke and D.F. Hedger

DEFENCE ORGANISATION

Defence Science and Technology Organisation

Chief Defence Scientist
FAS Science Policy
AS Science Corporate Management
AS Science Industry Interaction
} shared copy

Counsellor Defence Science, London (Doc Data Sheet only)
Counsellor Defence Science, Washington
Senior Defence Scientific Adviser/Scientific Adviser Policy and Command (shared copy)
Navy Scientific Adviser
Scientific Adviser - Army (Doc Data Sheet and distribution list only)
Air Force Scientific Adviser
Director Trials

Aeronautical And Maritime Research Laboratory

Director (AMRL)
Chief, Maritime Operations Division
Dr A. Theobald, MOD Sydney
Dr K. Benke, MOD Melbourne
Mr D. Hedger, MOD Melbourne
Mr J. Thompson, MOD Sydney
Dr J. Riley, MOD Salisbury
Dr R. Dawe, MOD Salisbury
Dr D. McMahon, MOD Salisbury
Dr R. O'Dowd, MOD Salisbury
Dr R. Neill, MOD Melbourne
Dr S. Anstee, MOD Sydney

Dr P. Hughes, AOD Fishermens Bend
Dr M. Mason AOD Fishermens Bend
Dr S. Oldfield, AOD Fishermens Bend
Mr G. Murray, AOD Fishermens Bend
Mr N. Goldsmith, AED Fishermens Bend

DSTO Library

Library Fishermens Bend
Library Maribyrnong
Main Library DSTOS (2 copies)
Library, MOD, Pyrmont (Doc Data sheet)

Defence Central

OIC TRS, Defence Central Library
Officer in Charge, Document Exchange Centre, 1 copy
*US Defence Technical Information Centre, 2 copies
*UK Defence Research Information Centre, 2 copies
*Canada Defence Scientific Information Service, 1 copy
*NZ Defence Information Centre, 1 copy
Defence Intelligence Organisation
Library, Defence Signals Directorate (Doc Data Sheet only)

Army

Director General Force Development (Land), (Doc Data Sheet)

Navy

Director General Force Development (Sea),

SO (Science), Director of Naval Warfare, Maritime Headquarters Annex, Garden Island, NSW 2000. (Doc Data Sheet only)

Navy and HQADF

Mine Sweeping Project Director (MSPD), CP2-3-02, Campbell Park Offices, Canberra.
Commander Australian Minewarfare Forces (CAMF), HMAS Waterhen, Waverton, NSW.
Deputy Director Mine Warfare Development (DDMWD), A-3-02, Russell Offices, Canberra.
Director Minor Project Development (DMPD), MHQ, Potts Point ,NSW.
Mine Warfare Systems Centre Project Director (MWSCPD), CP2-2-19, Campbell Park Offices, Canberra, ACT.
MWOSS, HMAS Waterhen, Waverton, NSW.
Mine Sweeping Project Officer (MSPO), CP2-3-02, Campbell Park Offices, Canberra.
Mine Warfare Operations Officer (MWOO), HMAS Waterhen, Waverton, NSW.
Mine Warfare Route Survey Officer (MWRSO), HMAS Waterhen, Waverton, NSW.
Commanding Officer (CO), AM Brolga, HMAS Waterhen, Waverton, NSW.
COMAUSMINDIVFOR, HMAS Waterhen, Waverton, NSW.

UNIVERSITIES AND COLLEGES

Australian Defence Force Academy
Library
Head of Aerospace and Mechanical Engineering
Senior Librarian, Hargrave Library, Monash University

OTHER ORGANISATIONS

NASA (Canberra)
AGPS

ABSTRACTING AND INFORMATION ORGANISATIONS

INSPEC: Acquisitions Section Institution of Electrical Engineers
Library, Chemical Abstracts Reference Service
Engineering Societies Library, US
American Society for Metals
Documents Librarian, The Center for Research Libraries, US

INFORMATION EXCHANGE AGREEMENT PARTNERS

Acquisitions Unit, Science Reference and Information Service, UK
Library - Exchange Desk, National Institute of Standards and Technology, US

SPARES (10 copies)

Page classification: UNCLASSIFIED

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
DOCUMENT CONTROL DATA

1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)

2. TITLE Improving Feature Perception in Sonar Displays by Contrast Normalisation and Enhancement	3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION) Document (U) Title (U) Abstract (U)
4. AUTHOR(S) K.K. Benke and D.F. Hedger	5. CORPORATE AUTHOR Aeronautical and Maritime Research Laboratory PO Box 4331 Melbourne Vic 3001

6a. DSTO NUMBER DSTO-TR-0302	6b. AR NUMBER AR-009-623	6c. TYPE OF REPORT Technical Report	7. DOCUMENT DATE February 1996

8. FILE NUMBER 510/207/0453	9. TASK NUMBER ADS 94/194	10. TASK SPONSOR DGFD(SEA)	11. NO. OF PAGES 13	12. NO. OF REFERENCES 10

13. DOWNGRADING/DELIMITING INSTRUCTIONS	14. RELEASE AUTHORITY Chief, Maritime Operations Division

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT

Approved for public release

OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE CENTRE, DIS NETWORK OFFICE, DEPT OF DEFENCE, CAMPBELL PARK OFFICES, CANBERRA ACT 2600

16. DELIBERATE ANNOUNCEMENT

No limitations

17. CASUAL ANNOUNCEMENT Yes

18. DEFTEST DESCRIPTORS

Data Normalisation, Image Processing, Signal Processing, Human Factors

19. ABSTRACT

In seabed surveillance, the nonlinearity of the sonar display, together with variations in brightness and contrast arising from variability in the stored sonar data, will have a direct effect on the visual discrimination of seabed features. The loss of information at the man-machine interface is due to environmental and instrumentation effects, and can be partially corrected for in real-time (i.e. at video frame rates) if the data is digitised and available for computer processing. Methods are described for normalising 2-D sonar data and for correcting for luminance compression in the electronic display. Experimental results for sidescan sonar indicate that statistical normalisation and display calibration by gamma-compensation provide a standardised presentation of data. The procedure improves both the visibility of seabed features and the reliability of visual search during routine surveillance.

Page classification: UNCLASSIFIED